Logistics Management Institute

Demand Forecasting

AF401LN2

F. Michael Slay

LMI

August 1995

Demand Forecasting

AF401LN2

F. Michael Slay

Prepared pursuant to Department of Defense Contract MDA903-90-C-0006. The views expressed here are those of the Logistics Management Institute at the time of issue but not necessarily those of the Department of Defense. Permission to quote or reproduce any part except for Government purposes must be obtained from the Logistics Management Institute.

Logistics Management Institute
2000 Corporate Ridge
McLean, Virginia 22102-7805

Contents

Contents (Continued)

Contents (Continued)

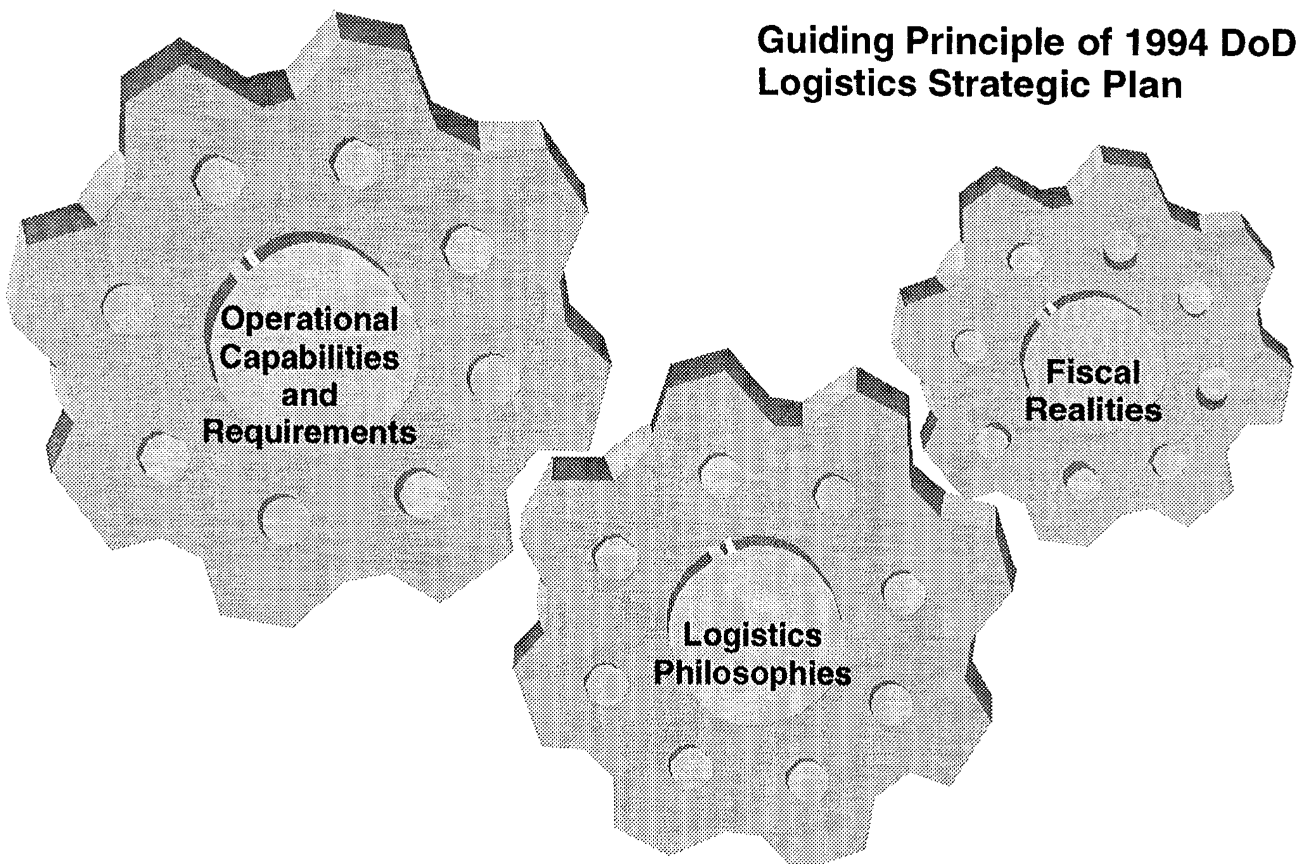
INTRODUCTION

In 1994, a new procedure for wartime demand forecasting was briefed to the Air Force logistics (LG) and the planning and operations (XO) communities. This methodology was approved and is currently being implemented in the mobility readiness spares package (MRSP) requirements computations systems.

This briefing book documents those briefings and serves as the first step in documenting the demand forecasting methodology. A full technical report will follow.

"THE COST AND 'FOOTPRINT' OF LOGISTICS SUPPORT MUST BE REDUCED SUBSTANTIALLY WITHOUT REDUCING READINESS"

Guiding Principle of 1994 DoD Logistics Strategic Plan



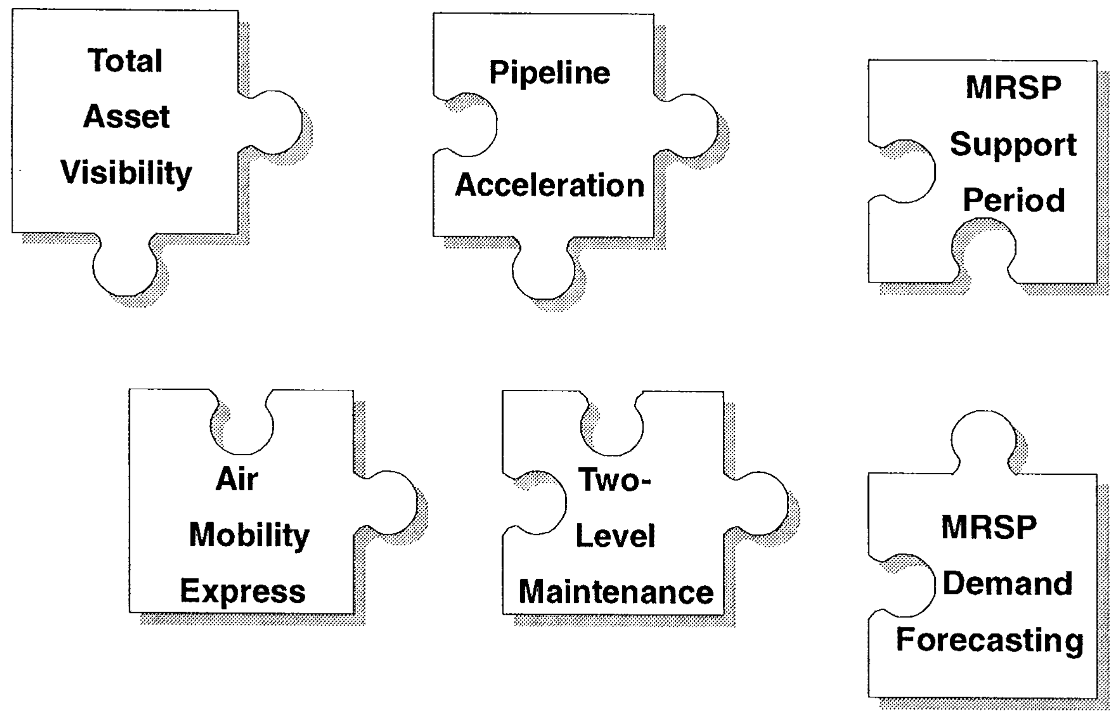
THE COST

This briefing is about our search for a better way to forecast wartime spare parts demand and its impact upon MRSPs.

While performing this research, we kept in mind that logistics must mesh with both operational requirements and fiscal realities.

We must not compromise on maintaining operational capabilities.

TOMORROW'S LOGISTICS REALITY IS DETERMINED BY HOW WE INTEGRATE TODAY'S EVOLVING LOGISTICS PHILOSOPHIES



TOMORROW'S LOGISTICS REALITY

In addition to addressing other concerns, our recommendations needed to complement the many ongoing "Lean Logistics" initiatives.

While demand forecasting is not explicitly a part of Lean Logistics, it must be suitable for the Lean Logistics environment.

DEMAND FORECASTING OVERVIEW

- Background
  - New WMP-5 published in 1993
  - Flying programs changed significantly
    - Many MRSP kit costs rose dramatically
    - Current kits assess poorly under new WMP
- Problems
  - MRSP costs not affordable nor believable
  - MRSP assessments not credible
  - These problems result from flying hour-based demand forecasts
- Solution
  - Develop better demand forecasting methods

DEMAND FORECASTING OVERVIEW

In 1993, a new WMP-5 (War and Mobilization Plan, Volume 5) was published. Reflecting Desert Shield/Desert Storm experience, these taskings were developed with the Regional Conflict Model. Unfortunately, they caused kit costs to rise precipitously.

Furthermore, assessment of current kits against the new WMP-5 resulted in unacceptable C-ratings.

These problems were symptomatic of a fundamental credibility problem within our computational models. This was caused by our use of traditional, flying hour-based demand forecasting methods in combination with the new WMP-5 flying programs.

Essentially, we needed to determine how to take demand data from peacetime flying programs and extrapolate them to wartime scenarios with much longer average sortie durations (ASDs).

BACKGROUND

The MRSP Requirements Computation Process

- Wartime demand computation
  - Total component flying hours projected
  - Wartime demands = projected flying hours/MTBF
- Requirements computation
  - Wartime repair (if any) modeled
  - Stock levels optimize availability vs. cost
- Nonoptimized (NOP) components
  - Special cases where model is overridden

Must improve demand forecasting without changing the process

BACKGROUND

Traditionally, we started the forecasting computations by projecting an item's total wartime flying hours. The item's demands were then simply its total flying hours divided by its mean time between failures (MTBF).

Stock levels were computed by factoring in deployed maintenance capabilities and each item's relative contribution to availability. MRSP stockage models add spares one at a time, until the expected aircraft availability meets the targeted direct support objective (DSO).

Human judgment can also influence stockage when failure patterns do not fit traditional flying hour-based forecasts. These items are declared nonoptimized (NOP) and their levels are set by hand.

This computation process was not broken, but a portion of it needed refining.

IMPACT OF BUY KIT WMP CHANGES
(Gross Requirement for a 30-Day Support Period)

	1986 WMP		1993 WMP		% Changes (from 1986)		
	Flying hours	Cost ($ millions)	Flying hours	Cost ($ millions)	Sorties	Flying hours	Cost
F-15C	1,341	27.9	3,338	79.3	-11	+149	+184
F-15E	2,019	33.6	1,984	19.0	-9	-2	-43
F-16C	1,455	28.3	2,153	27.5	+2	+48	-3
A-10A	2,016	6.0	3,432	12.9	+24	+70	+115

- Moratorium placed on using the 1993 WMP-5 for MRSP requirements computations and assessments (exception for F-15E)
- Problem: We are still building kits for WWIII, and we are assessing today's capability against yesterday's tasking

IMPACT OF BUY KIT WMP CHANGES

Logisticians have long suspected that pure flying hour-based demand forecasts would overstate requirements in certain cases. The 1993 WMP-5 appeared to contain many such cases.

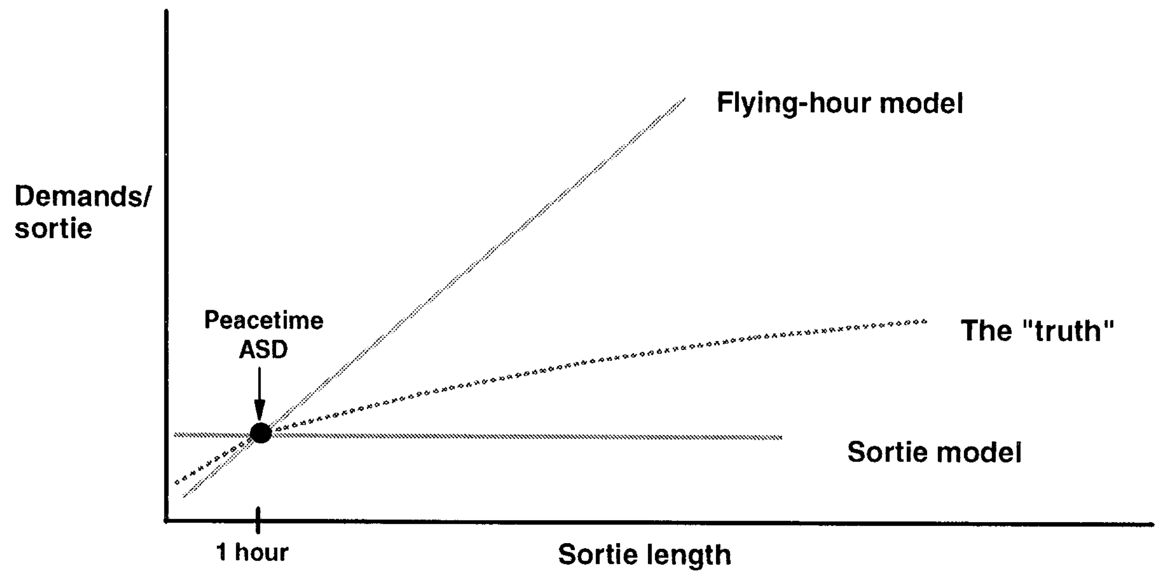
For example, the F-15C shows 1993 WMP-5 flying hours and kit costs that are almost triple the 1986 WMP-5, even though the number of sorties tasked actually drops 11 percent.

Seeing results like these, in March 1993, United States Air Force Deputy Chief of Staff for Logistics, AF/LG placed a moratorium on using the new WMP-5 for MRSP kit computations and assessments. In 1994, the F-15E was exempted from this moratorium, but the moratorium remained in force for all other U.S. Air Force aircraft.

Unfortunately, that meant we were building and assessing kits against an archaic warfighting scenario.

FORECASTING DEMANDS

- Assuming that demands are proportional to flying hours tends to overstate demands
- A pure sortie-based approach would tend to understate demands
- The "truth" is in between—and individual parts may be sortie-driven, flying hour-driven, or a combination thereof



FORECASTING DEMANDS

The key to lifting the moratorium was finding a better forecast method.

There are, however, many ways to forecast demands. This graph displays demands per sortie as a function of sortie length.

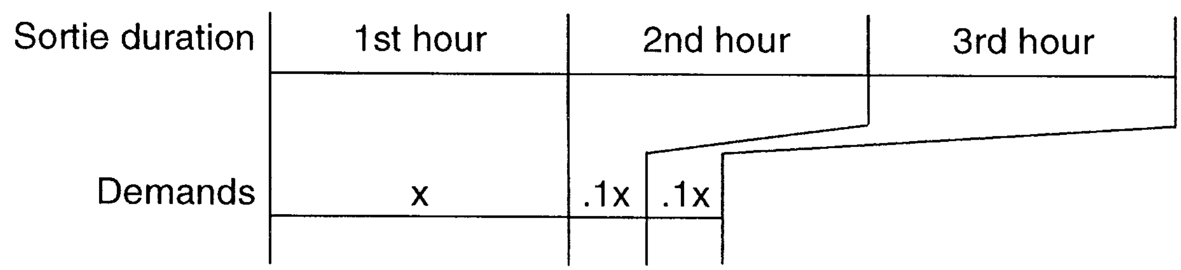
With the pure flying hour model, demands are directly proportional to sortie length. Thus, a two-hour sortie has twice the demands of a one-hour sortie.

With the pure sortie model, the demand rate per sortie is constant regardless of sortie length. Thus, a two-hour sortie has the same demand rate as a one-hour sortie.

We know that the truth is actually somewhere between these two extremes. Perhaps a two-hour sortie has 10 percent more demands than a one-hour sortie.

DECELERATION

- Additional hours on the sortie have decelerated demand



After the first hour, each additional hour adds 10% more demands

- The deceleration factor can be derived from the aircraft-specific maintenance history by linear regression

DECELERATION

Here is a picture of how the truth might work.

Suppose the 10 percent approach is correct. If the demand rate for a one-hour sortie is x, then adding a second hour to the sortie adds .1x to the underlying demand rate. Adding a third hour to the sortie length adds another .1x to the demand rate, and so forth.

In other words, the demand rate for flying beyond the first hour is "decelerated." That is, the demand rate for each hour, over and above the first hour, is only 10 percent that of the first hour's base line rate.

ANALYTICAL RESULTS

- Previous airlift studies show failures are more sortie-dependent than flying hour-dependent
  - Fighters may be even less flying hour-dependent than airlift
- Desert Shield/Storm experience
  - Longer sorties than peacetime
  - Failures per sortie much less than expected
- CAMS/REMIS analysis
  - Failures were approximately 10% flying hour — 90% sortie driven

No support for pure flying-hour based demand forecasting

ANALYTICAL RESULTS

We used three different approaches to examine this forecasting problem.

First — An investigation of the literature on forecasting demands. Almost all of the prior research focused on bombers and airlift — since they have a wide range of sortie durations. For these aircraft, the general result is that demands are closer to being purely sortie-dependent than to purely flying hour-dependent. However, we were more interested in fighters than in bombers and airlift, since that is the primary focus of the 1993 WMP-5 changes.

Fighter demands may be even less flying hour-dependent than bombers and airlift. Whereas a short fighter sortie involves takeoff, fighting and landing, a long sortie requires a significant amount of cruising to reach and return from the target. These cruising segments are not as taxing on the aircraft as the rest of the mission. In contrast, the fifth hour of an airlift flight is pretty much the same as the first, so the stresses on the aircraft are more consistent throughout the sortie's duration.

Second — An analysis of data from Desert Shield/Storm (DSS). DSS had longer sorties than peacetime experience, yet the failures per sortie were similar to the peacetime rate — much less than we expected using the pure flying hour-based forecast. Due to other factors, such as climate, the DSS data are inconclusive but strongly suggest that failures are not purely flying hour-dependent.

Third — Gathering and analysis of Core Automated Maintenance System/Reliability and Maintainability Information System (CAMS/REMIS) maintenance and sortie data for over 400,000 sorties for many different fighter aircraft. Individually, the results varied and were, for some aircraft, statistically insignificant. However, the aggregate results show that the 10 percent approach is correct. That is, a two-hour sortie breaks about 10 percent more parts than a one-hour sortie.

Overall, we found no support — in the literature, in the DSS data, or in the CAMS/REMIS data — for using pure flying hour-based demand forecasts. Given these conclusions, the next step was to evaluate the deceleration method's impact upon kit costs.

IMPACT OF PROPOSED DEMAND FORECASTING MODELS ON F-15C/D[a] 30-DAY MRSPs

Model	3-Level maintenance[b]		Transitional 2LM[b]	
	Cost ($ millions)	Weight and cube lbs. ($ft.^3$)	Cost ($ millions)	Weight and cube lbs. ($ft.^3$)
Current kit (1986 WMP-5)	14.7	22,000 (2,000)	20.5	22,000 (2,000)
Pure flying hour	41.2	45,000 (4,800)	68.2	57,000 (5,600)
10% flying hour — 90% sortie	7.2	18,000 (1,700)	16.5	22,000 (2,000)
Pure sorties	4.0	15,000 (1,400)	9.4	18,000 (1,600)

(a) 18 PAA contingency kit, 1993 WMP-5.
(b) Figures include NOPed items ($2.4 million; 14,000 lbs.; 1,300 $ft.^3$).

IMPACT OF PROPOSED DEMAND MODEL

Understanding the cost impact requires us to consider three separate policy impacts. Let's focus on today's fielded contingency kit for an F-15C squadron.

- If the Air Force simply overlays the 1993 WMP-5 rates and factors on today's kits, lifting the moratorium drives the kit cost up (from $14.7 million to $41.2 million). This assumes a pure flying hour-based demand forecast.

- Implementing the 10 percent deceleration demand forecast method drives the cost down (from $41.2 million to $7.2 million). However, this still assumes a significant amount of deployed maintenance capability [3-level maintenance (3LM)].

- Finally, incorporating 2-level maintenance (2LM) [converting all 2LM national stock numbers to remove and replace (RR)] drives the cost up (from $7.2 million to $16.5 million).

Combining all three effects together, we can compare today's fielded kit to tomorrow's kit. On balance, tomorrow's recommended kit will be slightly more expensive than today's kit, yet tailored to a more rigorous WMP-5 tasking.

Just as important as the purely budgetary impacts are the operational risks associated with decelerated demand forecasts.

RISK ASSESSMENT – F-15C/D

Percent of 30-Day Aggregate WMP-5 Sorties Flown

Kit assessed [a]	Kit cost ($ millions)	Demand model (1993 WMP-5 flying program — transitional 2LM)			
		Pure flying hour model	20% flying hour model	10% flying hour model	Pure sortie model
Current kit (1986 WMP-5, 3LM)	14.7	65.8%	91.9%	96.4%	99.0%
Pure flying hour kit (2LM)	68.2	100.0	100.0	100.0	100.0
10% Flying hour — 90% sortie kit (2LM)	16.5	80.8	99.2	100.0	100.0
Pure sortie kit (2LM)	9.4	72.2	96.5	98.9	100.0

[a] 18 PAA F-15C contingency kit.

10% flying hour — 90% sortie kit — low risk of lost sorties

RISK ASSESSMENT — F-15C/D
Percent of 30-Day Aggregate WMP-5 Sorties Flown

What if we're wrong? What would happen if the Air Force built a kit using the 10 percent deceleration model, but the truth was something else? How robust is the proposed 10 percent deceleration-based kit?

To answer these questions, we evaluated the kits under various scenarios. Using a Monte Carlo simulation similar to Dynamic Multi-Echelon Technique for Recoverable Item Control (Dyna-METRIC) 6, we assessed each kit's performance under four different demand environments.

- Demands turn out to be purely sortie-based
- Demands are 10 percent flying hour/90 percent sortie-based
- Demand are 20 percent flying hour/80 percent sortie-based
- Demands are purely flying hour-based.

Of greatest interest is the 10 percent flying hour kit evaluated under the 20 percent flying hour environment. Here we see that even if demands actually are twice as sensitive to sortie duration as we thought, an F-15C squadron could still fly 99 percent of its planned sorties.

Even in the unlikely and taxing case where demands are purely driven by flying hours, a squadron could still fly over 80 percent of its planned sorties. However, we found no evidence to support this pure flying hour model: not in the literature, nor the DSS experience, nor the REMIS data.

While the 10 percent deceleration method yields kits with very low risk of lost sorties, we can quantify this risk another way by asking how much express resupply would be needed to prevent any lost sorties.

RISK ASSESSMENT – F-15C/D

Estimated 30-Day "Desert Express" Requirement — lbs. (ft.^{3})[a]

Kit assessed [b]	Demand model (1993 WMP-5 flying program — transitional 2LM)			
	Pure flying hour model	20% flying hour model	10% flying hour model	Pure sortie model
Current kit (1986 WMP-5, 3LM)	8,796 (671)	1,360 (92)	--	--
Pure flying hour kit (2LM)	--	--	--	--
10% flying hour — 90% sortie kit (2LM)	5,540 (421)	171 (12)	--	--
Pure sortie kit (2LM)	8,632 (676)	633 (43)	132 (9)	--

(a) Total expedited weight (& cube) to fly 100% of WMP-5 program.
(b) 18 PAA F-15C contingency kit.

10% flying hour — 90% sortie kit — minimal expedited airlift required

RISK ASSESSMENT — F-15C/D
Estimated 30-Day "Desert Express" Requirement — lbs. ($ft.^3$)

Here we see the same kits evaluated under the same hypothetical demand environments in terms of the Desert Express-type resupply required to fly 100 percent of planned sorties.

Again, the risk is low. Even in the worst of these cases, less than 3 tons would need to be expedited for the 10 percent deceleration-based kit to fly 100 percent of planned sorties. Now, recall that the pure flying hour kit — capable of flying 100 percent of the sorties even in the worst case — weighs 18 tons more than the 10 percent deceleration-based kit. Thus, even in the unlikely case that the decelerated demand forecasting method is completely wrong, the 3 tons of expediting is more than balanced by the 18 tons of initial airlift saved.

The F-15C/D was our analytical prototype for this study, but similar results hold for other mission design series (MDS) aircraft, as well.

MDS SUMMARY

Contingency Kit Costs and Percent of 1993 WMP-5 Tasking Flown

- F-15C/D (18 PAA, RRR kit)
  - Current (3LM) kit — $14.7 million; worst case — flies 65.8% of sorties
  - 10% FH (2LM) kit — $16.5 million; worst case — flies 80.8% of sorties
- A-10A (18 PAA, RR kit)
  - Current kit — $4.0 million; worst case — flies 98.5% of sorties
  - 10% FH kit — $4.4 million; worst case — flies 99.3% of sorties
- F-15E (18 PAA, RRR kit) (already using 1993 WMP-5)
  - Current (3LM) kit — $23.6 million; worst case — flies 99.7% of sorties
  - 10% FH (2LM) kit — $19.7 million; worst case — flies 98.3% of sorties

MDS SUMMARY

Here we summarize the risk analysis for the F-15C/D and the other MDSs.

The first bullet shows that for the F-15C/D, using the kit based 10 percent on flying hours and 2LM would increase the kit cost from $14.7 million to $16.5 million, but would lower the risk of lost sorties under the worst-case assumption that demand is actually determined solely by flying hours.

The second bullet shows that lifting the moratorium and implementing the 10 percent deceleration method raises the A-10A's kit cost from $4.0 million to $4.4 million with extremely low risk of lost sorties.

The third bullet shows the F-15E, which is a special case because the moratorium had already been lifted. Here we see that implementing the 10 percent method and 2LM further lowers the kit cost from $23.6 million to $19.7 million. Yet the risk of lost sorties is very low, even in the worst case.

These MDS-specific results are detailed in the appendix.

MDS SUMMARY (Cont.)

Contingency Kit Costs and Percent of 1993 WMP-5 Tasking Flown

- F-16C/D (18 PAA, RR kit) (lower DSO in 1993 WMP drives results)
  - Current kit — $8.6 million; worst case — flies 99.7% of sorties
  - 10% FH kit — $3.6 million; worst case — flies 98.9% of sorties
- F-111F (18 PAA, RRR kit w/2LM) (high DSO drives results)
  - Current kit — $81.0 million; worst case — flies 100% of sorties
  - 10% FH kit — $83.8 million; worst case — flies 100% of sorties
- F-117A (18 PAA, RR kit)
  - Current kit — $25.4 million; worst case — flies 91.6% of sorties
  - 10% FH kit — $27.4 million; worst case — flies 96.6% of sorties

MDS SUMMARY (Continued)

The F-16C is unique, in that the 1993 WMP-5 yields a much lower DSO than did the 1986 WMP. This lower DSO allows for more "Cann Birds" to be used as a source of supply. This dramatically reduces the kit cost (from $8.6 million to $3.6 million).

Even so, the risk of lost sorties is very low, even in the worst-case scenario.

The F-111F kit cost rises (from $81 million to $83.8 million) with lifting the moratorium and implementing the 10 percent deceleration method. Note that 2LM was already fully incorporated into the F-111F kit. Also, due to a particularly high DSO, there is no risk of lost sorties even in the worst case.

The F-117A kit cost also rises (from $25.4 million to $27.4 million) with lifting the moratorium and implementing the 10 percent method. Risk of lost sorties in the worst case is low.

These MDS-specific results are detailed in the appendix.

CONCLUSIONS

- Computing demands using decelerated sortie lengths is more accurate
  - Demands per sortie do not vary with a one-to-one proportion to sortie length
- The truth is closer to the pure sortie model than to the pure flying-hour model
- MRSP size is extremely sensitive to how demands are forecast
- Mission risk is low

CONCLUSIONS

The pure flying hour-based demand forecasting model is inappropriate for extrapolating peacetime demand data to significantly different wartime flying programs — demands per sortie are not directly proportional to sortie length. Decelerating the sortie length yields a more accurate demand model.

The truth is closer to the pure sortie model than to the pure flying hour model. However, the pure sortie model is not exactly right either. The truth falls between these two extremes — though closer to the pure sortie method.

The demand model has a dramatic effect on the size and cost of MRSP kits.

Yet the resulting kits do not put the mission at risk, and the risks can be further reduced with a moderate amount of expedited airlift.

RECOMMENDATIONS

- Implement corrected demand forecasting methodology now
- Lift requirements moratorium now
- Lift assessments moratorium as revised kits are fielded

RECOMMENDATIONS

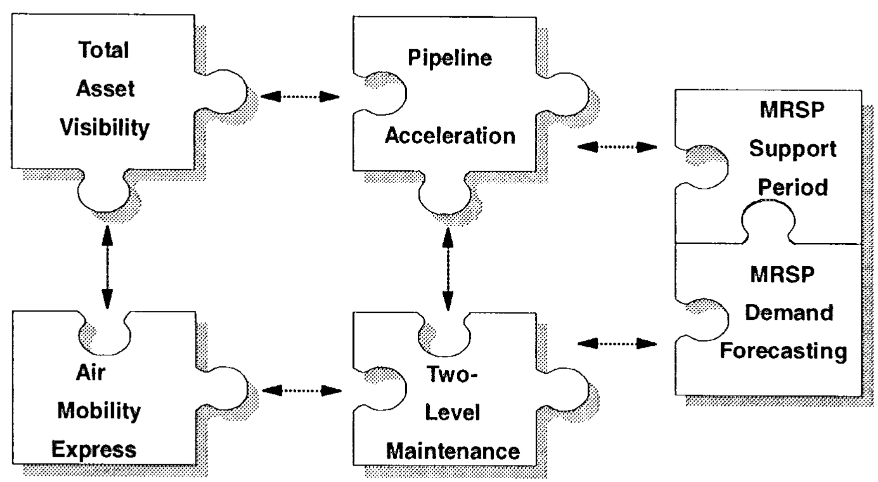
We recommended that:

- The deceleration demand forecasting method be implemented
- The requirements moratorium be lifted immediately, and
- The assessments moratorium be lifted as the revised kits are fielded.

The Air Force accepted these recommendations and has begun to implement them.

FUTURE EFFORTS

- Assist Air Force Materiel Command (AFMC) and using commands with implementing new MRSP demand forecasting methods
- Analyze bombers and airlift using REMIS data
- Reexamine MRSP support periods as lean logistics initiatives are implemented



- Explore work unit code unique demand forecasting alternatives

FUTURE EFFORTS

This is not the end of the line. Implementation will be hard work. LMI will assist AFMC in implementing the new demand forecasting methods. We must extend the analysis beyond fighters, to include all aircraft in the U.S. Air Force inventory.

Furthermore, as Lean Logistics takes shape, we must consider the interactions between the decelerated demand forecasting method and the various Lean Logistics initiatives. First among these is reducing the MRSP support period.

Also, we need to continue to pursue improving demand forecasting. Specifically, we hope to go beyond a one-size-fits-all model. We would expect, given enough time and data, to find that demand sensitivity to sortie duration varies by the type of system involved. For example, avionics may differ from engine components in their sensitivity to sortie duration. This is an ongoing Air Force initiative.

Appendix:
MDS-Specific Analyses

IMPACT OF PROPOSED DEMAND FORECASTING MODELS ON A-10A[a] 30-DAY MRSPs

Model	A-10A[b]	
	Cost ($ millions)	Weight and cube lbs. ($ft.^3$)
Current kit (1986 WMP-5)	4.0	23,000 (1,900)
Pure flying hour	5.5	24,000 (2,100)
10% flying hour — 90% sortie	4.4	23,000 (2,000)
Pure sorties	4.2	23,000 (2,000)

[a] 18 PAA contingency kit (RR), 1993 WMP-5.
[b] Figures include NOPed items ($3.5 million; 22,000 lbs.; 1,900 $ft.^3$).

RISK ASSESSMENT – A-10A

Percent of 30-Day Aggregate WMP-5 Sorties Flown

Kit assessed [a]	Kit cost ($ millions)	Demand model (1993 WMP-5 flying program)			
		Pure flying hour model	20% flying hour model	10% flying hour model	Pure sortie model
Current kit (1986 WMP-5)	4.0	98.5%	99.7%	99.8%	99.9%
Pure flying hour kit	5.5	100.0	100.0	100.0	100.0
10% flying hour — 90% sortie kit	4.4	99.3	99.9	100.0	100.0
Pure sortie kit	4.2	99.1	99.8	99.9	100.0

[a] 18 PAA A-10A contingency kit (RR).

10% flying hour — 90% sortie kit — low risk of lost sorties

RISK ASSESSMENT – A-10A

Estimated 30-Day "Desert Express" Requirement — lbs. ($ft.^3$)[a]

Kit assessed[b]	Demand model (1993 WMP-5 flying program)			
	Pure flying hour model	20% flying hour model	10% flying hour model	Pure sortie model
Current kit (1986 WMP-5)	276 (38)	62 (9)	38 (5)	14 (2)
Pure flying hour kit	--	--	--	--
10% flying hour — 90% sortie kit	133 (18)	17 (3)	--	--
Pure sortie kit	167 (22)	32 (4)	13 (1)	--

(a) Total expedited weight (and cube) to fly 100% of WMP-5 program.
(b) 18 PAA A-10A contingency kit (RR).

10% flying hour — 90% sortie kit — minimal expedited airlift required

IMPACT OF PROPOSED DEMAND FORECASTING MODELS ON F-4G[a] 30-DAY MRSPs

Model	F-4G [b]	
	Cost ($ millions)	Weight and cube lbs. (ft.^{3})
Current kit (1986 WMP-5)	33.0	28,400 (2,700)
Pure flying hour	60.3	41,100 (3,900)
10% flying hour — 90% sortie	32.2	26,500 (2,400)
Pure sorties	26.5	23,400 (2,100)

(a) 12 PAA contingency kit (2-level), 1993 WMP-5.
(b) Figures include NOPed items ($2.7 million; 10,000 lbs.; 768 ft.^{3}).

RISK ASSESSMENT – F-4G

Percent of 30-Day Aggregate WMP-5 Sorties Flown

Kit assessed [a]	Kit cost ($ millions)	Demand model (1993 WMP-5 flying program)			
		Pure flying hour model	20% flying hour model	10% flying hour model	Pure sortie model
Current kit (1986 WMP-5)	33.0	85.3%	98.8%	99.7%	100.0%
Pure flying hour kit	60.3	100.0	100.0	100.0	100.0
10% flying hour — 90% sortie kit	32.2	90.0	99.5	100.0	100.0
Pure sortie kit	26.5	84.5	98.3	99.4	100.0

(a) 12 PAA F-4G contingency kit (2-level).

10% flying hour — 90% sortie kit — low risk of lost sorties

RISK ASSESSMENT – F-4G

Estimated 30-Day "Desert Express" Requirement — lbs. ($ft.^3$)[a]

Kit assessed[b]	Demand model (1993 WMP-5 flying program)			
	Pure flying hour model	20% flying hour model	10% flying hour model	Pure sortie model
Current kit (1986 WMP-5)	1,275 (109)	44 (4)	8 (1)	--
Pure flying hour kit	--	--	--	--
10% flying hour — 90% sortie kit	803 (64)	28 (2)	--	--
Pure sortie kit	2,112 (171)	127 (9)	47 (3)	--

(a) Total expedited weight (and cube) to fly 100% of WMP-5 program.
(b) 12 PAA F-4G contingency kit (2-level).

10% flying hour — 90% sortie kit — minimal expedited airlift required

IMPACT OF PROPOSED DEMAND FORECASTING MODELS ON RF-4C[a] 30-DAY MRSPs

Model	RF-4C[b]	
	Cost ($ millions)	Weight and cube lbs. ($ft.^3$)
Current kit (1986 WMP-5)	11.0	19,600 (2,000)
Pure flying hour	13.3	21,900 (2,200)
10% flying hour — 90% sortie	6.7	13,900 (1,400)
Pure sorties	6.0	13,200 (1,300)

[a] 18 PAA contingency kit (2-level), 1993 WMP-5.
[b] Figures include NOPed items ($5.5 million; 12,200 lbs.; 1,200 $ft.^3$).

RISK ASSESSMENT – RF-4C

Percent of 30-Day Aggregate WMP-5 Sorties Flown

Kit assessed [a]	Kit cost ($ millions)	Demand model (1993 WMP-5 flying program)			
		Pure flying hour model	20% flying hour model	10% flying hour model	Pure sortie model
Current kit (1986 WMP-5)	11.0	98.7%	100.0%	100.0%	100.0%
Pure flying hour kit	13.3	100.0	100.0	100.0	100.0
10% flying hour — 90% sortie kit	6.7	94.5	99.9	100.0	100.0
Pure sortie kit	6.0	90.9	99.7	99.8	100.0

[a] 18 PAA RF-4C contingency kit (2-level).

10% flying hour — 90% sortie kit — low risk of lost sorties

RISK ASSESSMENT – RF-4C

Estimated 30-Day "Desert Express" Requirement — lbs. ($ft.^3$) [a]

Kit assessed [b]	Demand model (1993 WMP-5 flying program)			
	Pure flying hour model	20% flying hour model	10% flying hour model	Pure sortie model
Current kit (1986 WMP-5)	329 (31)	--	--	--
Pure flying hour kit	--	--	--	--
10% flying hour — 90% sortie kit	1,248 (124)	30 (3)	--	--
Pure sortie kit	1,306 (167)	90 (9)	30 (3)	--

(a) Total expedited weight (and cube) to fly 100% of WMP-5 program.
(b) 18 PAA RF-4C contingency kit (2-level).

10% flying hour — 90% sortie kit — minimal expedited airlift required

IMPACT OF PROPOSED DEMAND FORECASTING MODELS ON F-15E[a] 30-DAY MRSPs

Model	3-level maintenance[b]		Transitional 2LM[b]	
	Cost ($ millions)	Weight and cube lbs. ($ft.^3$)	Cost ($ millions)	Weight and cube lbs. ($ft.^3$)
Pure flying hour	23.6	19,000 (1,500)	24.3	19,000 (1,500)
10% flying hour — 90% sortie	19.6	15,000 (1,100)	19.7	15,000 (1,200)
Pure sorties	18.5	14,000 (1,100)	18.6	14,000 (1,100)

[a] 18 PAA contingency kit, 1993 WMP-5.
[b] Figures include NOPed items ($17.0 million; 13,000 lbs.; 900 $ft.^3$).

RISK ASSESSMENT – F-15E

Percent of 30-Day Aggregate WMP-5 Sorties Flown

Kit assessed [a]	Kit cost ($ millions)	Demand model (1993 WMP-5 flying program — transitional 2LM)			
		Pure flying hour model	20% flying hour model	10% flying hour model	Pure sortie model
Current kit (pure flying hour 3LM)	23.6	99.7	100.0	100.0	100.0
10% flying hour — 90% sortie kit (2LM)	19.7	98.3	99.8	100.0	100.0
Pure sortie kit (2LM)	18.6	97.1	99.6	99.8	100.0

[a] 18 PAA F-15E contingency kit.

10% flying hour — 90% sortie kit — low risk of lost sorties

RISK ASSESSMENT – F-15E

Estimated 30-Day "Desert Express" Requirement — lbs. ($ft.^3$)[a]

Kit assessed [b]	Demand model (1993 WMP-5 flying program — transitional 2LM)			
	Pure flying hour model	20% flying hour model	10% flying hour model	Pure sortie model
Current kit (pure flying hour, 3LM)	29 (4)	--	--	--
10% flying hour — 90% sortie kit (2LM)	613 (63)	53 (6)	--	--
Pure sortie kit (2LM)	837 (88)	139 (15)	61 (6)	--

(a) Total expedited weight (and cube) to fly 100% of WMP-5 program.
(b) 18 PAA F-15E contingency kit.

10% flying hour — 90% sortie kit — minimal expedited airlift required

IMPACT OF PROPOSED DEMAND FORECASTING MODELS ON F-16C/D[a] 30-DAY MRSPs

Model	F-16C/D[b]	
	Cost ($ millions)	Weight and cube lbs. ($ft.^3$)
Current kit (1986 WMP-5)	8.6	20,000 (1,900)
Pure flying hour	9.0	14,000 (1,300)
10% flying hour — 90% sortie	3.6	10,000 (800)
Pure sorties	2.9	10,000 (800)

(a) 18 PAA contingency kit (RR), 1993 WMP-5.
(b) Figures include NOPed items ($1.6 million; 8,000 lbs.; 600 $ft.^3$).

RISK ASSESSMENT – F-16C/D

Percent of 30-Day Aggregate WMP-5 Sorties Flown

Kit assessed [a]	Kit cost ($ millions)	Demand model (1993 WMP-5 flying program)			
		Pure flying hour model	20% flying hour model	10% flying hour model	Pure sortie model
Current kit (1986 WMP-5)	8.6	99.7%	100.0%	100.0%	100.0%
Pure flying hour kit	9.0	100.0	100.0	100.0	100.0
10% flying hour — 90% sortie kit	3.6	98.9	99.9	100.0	100.0
Pure sortie kit	2.9	98.5	99.8	99.9	100.0

[a] 18 PAA F-16C contingency kit.

10% flying hour — 90% sortie kit — low risk of lost sorties

RISK ASSESSMENT – F-16C/D

Estimated 30-Day "Desert Express" Requirement — lbs. ($ft.^3$)[a]

Kit assessed[b]	Demand model (1993 WMP-5 flying program)			
	Pure flying hour model	20% flying hour model	10% flying hour model	Pure sortie model
Current kit (1986 WMP-5)	50 (5)	--	--	--
Pure flying hour kit	--	--	--	--
10% flying hour — 90% sortie kit	157 (17)	5 (1)	--	--
Pure sortie kit	244 (24)	15 (2)	7 (1)	--

(a) Total expedited weight (and cube) to fly 100% of WMP-5 program.
(b) 18 PAA F-16C/D contingency kit.

10% flying hour — 90% sortie kit — minimal expedited airlift required

IMPACT OF PROPOSED DEMAND FORECASTING MODELS ON F-111F[a] 30-DAY MRSPs

Model	F-111F[b]	
	Cost ($ millions)	Weight and cube lbs. ($ft.^3$)
Current kit (1986 WMP-5)	81.0	68,000 (7,300)
Pure flying hour	109.3	79,000 (8,600)
10% flying hour — 90% sortie	83.8	69,000 (7,400)
Pure sorties	72.3	64,000 (6,900)

(a) 18 PAA contingency kit (2-level), 1993 WMP-5.
(b) Figures include NOPed items ($4.3 million; 20,000 lbs.; 2,000 $ft.^3$).

RISK ASSESSMENT – F-111F

Percent of 30-Day Aggregate WMP-5 Sorties Flown

Kit assessed [a]	Kit cost ($ millions)	Demand model (1993 WMP-5 flying program)			
		Pure flying hour model	20% flying hour model	10% flying hour model	Pure sortie model
Current kit (1986 WMP-5)	81.0	100.0%	100.0%	100.0%	100.0%
Pure flying hour kit	109.3	100.0	100.0	100.0	100.0
10% flying hour — 90% sortie kit	83.8	100.0	100.0	100.0	100.0
Pure sortie kit	72.3	100.0	100.0	100.0	100.0

[a] 18 PAA F-111F contingency kit (2-level).

10% flying hour — 90% sortie kit — low risk of lost sorties

RISK ASSESSMENT – F-111F

Estimated 30-Day "Desert Express" Requirement — lbs. (ft.^{3})[a]

Kit assessed[b]	Demand model (1993 WMP-5 flying program)			
	Pure flying hour model	20% flying hour model	10% flying hour model	Pure sortie model
Current kit (1986 WMP-5)	483 (67)	75 (10)	8 (1)	--
Pure flying hour kit	--	--	--	--
10% flying hour — 90% sortie kit	447 (61)	63 (8)	--	--
Pure sortie kit	925 (123)	232 (30)	77 (10)	--

(a) Total expedited weight (and cube) to fly 100% of WMP-5 program.
(b) 18 PAA F-111F contingency kit (2-level).

10% flying hour — 90% sortie kit — minimal expedited airlift required

IMPACT OF PROPOSED DEMAND FORECASTING MODELS ON F-117A[a] 30-DAY MRSPs

Model	F-117A[b]	
	Cost ($ millions)	Weight and cube lbs. ($ft.^3$)
Current kit (1986 WMP-5)	25.4	32,000 (3,200)
Pure flying hour	35.0	57,000 (6,500)
10% flying hour — 90% sortie	27.4	37,000 (3,800)
Pure sorties	25.9	34,000 (3,400)

(a) 18 PAA contingency kit (RR), 1993 WMP-5.
(b) Figures include NOPed items ($20.5 million; 21,000 lbs.; 1,700 $ft.^3$).

RISK ASSESSMENT – F-117A

Percent of 30-Day Aggregate WMP-5 Sorties Flown

Kit assessed [a]	Kit cost ($ millions)	Demand model (1993 WMP-5 flying program)			
		Pure flying hour model	20% flying hour model	10% flying hour model	Pure sortie model
Current kit (1986 WMP-5)	25.4	91.6%	99.5%	99.9%	100.0%
Pure flying hour kit	35.0	100.0	100.0	100.0	100.0
10% flying hour — 90% sortie kit	27.4	96.6	99.9	100.0	100.0
Pure sortie kit	25.9	93.1	99.6	99.9	100.0

[a] 18 PAA F-117A contingency kit.

10% flying hour — 90% sortie kit — low risk of lost sorties

RISK ASSESSMENT – F-117A

Estimated 30-Day "Desert Express" Requirement — lbs. ($ft.^3$)[a]

Kit assessed[b]	Demand model (1993 WMP-5 flying program)			
	Pure flying hour model	20% flying hour model	10% flying hour model	Pure sortie model
Current kit (1986 WMP-5)	2,736 (390)	511 (72)	192 (27)	33 (5)
Pure flying hour kit	--	--	--	--
10% flying hour — 90% sortie kit	1,380 (201)	104 (15)	--	--
Pure sortie kit	2,344 (335)	450 (49)	144 (20)	--

(a) Total expedited weight (and cube) to fly 100% of WMP-5 program.
(b) 18 PAA F-117A contingency kit.

10% flying hour — 90% sortie kit — minimal expedited airlift required

GLOSSARY

2LM	=	two-level maintenance
3LM	=	three-level maintenance
AFMC	=	Air Force Materiel Command
ASD	=	average sortie duration
CAMS/REMIS	=	Core Automated Maintenance System/Reliability and Maintainability Information System
DSO	=	direct support objective
DSS	=	Desert Shield/Storm
FH	=	flying hour
LG	=	logistics
MDS	=	mission design series
MRSP	=	mobility readiness spares package
MTBF	=	mean time between failures
NOP	=	nonoptimized
PAA	=	primary aircraft authorization
RR	=	remove and replace

RRR = remove, repair, and replace

WMP-5 = War and Mobilization Plan, Volume 5

REPORT DOCUMENTATION PAGE

Form Approved
OPM No.0704-0188

1. AGENCY USE ONLY *(Leave Blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	August 1995	Final

4. TITLE AND SUBTITLE

Demand Forecasting

5. FUNDING NUMBERS

C DASW01-95C-0019

PE 0902198D

6. AUTHOR(S)

F. Michael Slay

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Logistics Management Institute
2000 Corporate Ridge
McLean, VA 22102-7805

8. PERFORMING ORGANIZATION REPORT NUMBER

LMI– AF401LN2

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

United States Air Force/LGSI
The Pentagon
Washington, D.C.

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

A: Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Although the United States Air Force, and other Military Services, forecast failures for many aircraft components on the basis of flying hours, it has long been recognized that the situation is not that simple. New war plans adopted by the Air Force in 1993 and reflecting Desert Storm experience and a regional contingency orientation made it crucial to improve forecasting methods. We examined data for over 200,000 sorties and show that failures for longer sorties are not strictly proportional to flying hours, and quantify the errors caused by assuming that they are. We demonstrate a method for correcting for this error and apply this correction to a number of fighter deployment spares packages. We compute the new costs and test the robustness of the new packages under various scenarios.

14. SUBJECT TERMS

Inventory, readiness, spares, demand forecast, demands, failure rates, demand rates

15. NUMBER OF PAGES

60

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL